EXPLOSION OF STEAM BOILERS.

MEMORIAL

OF

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January 15, 1838.

Ordered to lie upon the table.

To the Committee of Congress having under consideration the subject of the explosion of steam boilers.

Gentlemen: The frequent and dreadful explosions of steam boilers have made such just excitement and alarm in the public mind, that it is evident, as has been observed by many of the public journals, something ought to be done to remedy the evil. Believing that it may be wholly remedied, and steam engines rendered wholly harmless, I submit my views on this subject to your consideration. In these remarks, I shall notice a few things which have been published in the Franklin Journal, now called the Franklin Institute.

Dr. Hare, vol. 2, p. 175, says: "While I coincide in the opinion that overheating may be one cause of explosion, I am far from considering that the only cause of danger." There the Doctor is right: for more than one cause must unite to produce an effect in any part of the kingdom of nature. In this case, the overheating, the undue deficiency of water, and the undue enlargement of the steam chamber, must all unite to produce an explosion.

In page 147 he says: "The production of explosive gas is contrary to the well-established principles of chemistry." To this hypothesis I only say, that nature, in many parts of her works, has a chemistry wholly unknown to man; and, if we were to deny effects because we cannot solve their causes by our rules of chemistry, we should find facts enough in the works of nature, well known to exist, to deny. In these cases, we well know that explosions do take place. Because we cannot solve these things by the notions we have adopted, shall we deny them; or shall we conclude that we have not yet hit upon the right theory of that part of natural philosophy? The latter appears much more rational to me. Besides, this is the way to arrive at true philosophy in the end: when we find our rules to fail, to search for others; for we find that the laws of nature never change to accommodate our opinions.

Thomas Allen, print.

Mr. Perkins, vol. 3, p. 417, says: "If any part of the boiler containing the steam becomes of a higher temperature than the water, from want of a sufficient supply, the steam will become surcharged with caloric, without acquiring any proportionable elasticity." I shall not deny this doctrine, but turn it to my own account in the following remarks.

The editor of the Franklin Institute, vol. 2, p. 71, says "that the idea of burning steam is no more rational than it would be to set a river on fire; steam is as incombustible as water, and is water in an attenuated state." In one sense the editor is right, for steam in its first development from water is incombustible, and will queneh fire as quick as water. But we must consider that steam, from its first development from water to the time of its explosion in a boiler, has by time and heat undergone many changes, of which we are entirely ignorant, and probably forever shall be. But we must consider that every substance of which we have any knowledge, at some given degree of heat, is capable of ignition; and it is already known, by experience, that water can be heated red hot, and that steam, by a proper apparatus, can be converted into a blaze of fire. And it is a fact which no scientific man will deny at this day, that water, and probably steam, in its various developments, even to explosion, is a compound, and acquires properties in all its various stages, of which we, as yet, haveno distinct knowledge. And, speaking of a late explosion, he says: "Had this explosion been the consequence of explosive gas, flame would have filled the vessel, and light articles would have been burnt, and people, too, instead of being scalded." To this I need only answer, that in the explosion of boilers, the flame and water, from the instantaneous and immense force, are so mixed that the flame is probably extinguished instantaneously. And he also says "that no reason can be given why the explosion should not have been caused by steam alone." To this I need only say, as I have before, that one cause can never produce any effect.

He says, page 72, "if the oxygen of the water could be combined with the iron of the boiler, the hydrogen would be incapable of explosion." To this I need only answer, that when we see effects produced, it is idle to say that they can only be produced by our rules. Nature, in her simple and uniform method of producing effects, laughs at the wisdom of man, and pays no deference thereto until he happens to hit upon her plan. The various and unsuccessful experiments which have been tried in all ages, are abundant proof of this. He adds, "it is believed that these explosions take place when the water is deficient in the boiler." This hypothesis is undoubtedly true, as I shall endeavor to show.

Before I enter into any explanation of my own views of the subject, I would remark, as a general principle, that we are to make a specific difference between bursting and explosion. By bursting we should understand a rupture of the weaker part of the boiler, whereby the steam blows off like a bellows, which effects little or no injury. Of this species the lifting of the safety-valve is one; its weight being specifically less than the strength of the boiler, it lifts when the press of steam exceeds its weight, and lets off the surplus steam, till the pressure is reduced, and then closes by its own gravity. This effect is produced by the regular accumulation of a super quantity of steam, and, instead of giving any cause of alarm, is always evidence of safety.

Explosion is altogether different; it is the sudden, immeasurable, and uncontrollable accumulation and expansion of the spheres of the different gases upon each other, by the effect of combustion, and in a manner wholly unknown, and, as far as present knowledge extends, irresistible. Such are the effects of all the different kinds of powder. We well know their effects, but nothing of the manner of their operation. The effect of heat upon all fluids is the accumulation and expansion of the spheres of the different gases upon one another, and the constant and regular development of new gases, and the expansion of their spheres upon each other according to the degree and intensity of the heat. Cold, according to its degree, condenses back, in all nature, in the same exact order and ratio; and so these effects operate alternately, from solid ice to the rarest possible expansion, and back again to solid ice; and heat, at some given degree, changes all solids to fluids.

On this principle the labor of the steam engine is kept up, being on the same principles as the revolution of the seasons and the planetary motions, the due irregularities and balances of heat and cold, and is probably the only imitation which man will ever be able to make of the perpetual motion; and this should cause no small admiration in the philosophical mind, that the art of man, even on so small a scale, has been able to imitate the works of God.

Upon these premises, my conclusion is that explosion in the steam boiler is produced by the same causes as the electrical explosion in the heavens; the only difference being its immense insignificance. I ground my opinion entirely upon the similarity in the effect produced, comparing the works of man with the works of God.

When we treat of subjects entirely beyond the reach of our senses and the test of experiment, and which we can neither confine nor handle, analogy is the only mode of reasoning to which we have access. In these steam explosions, I suppose these electrical gases are accumulated on the same principles as they are in a thunder cloud in the heavens. The true theory of the electrical explosions in the heavens was well settled by Dr. Franklin, in the first experimental development of it, and has stood the test of experiment since his time, and probably will forever, notwithstanding the many and great efforts which have been made to overthrow it. The substance of his theory is, that explosion is caused by the sudden mutual and violent attraction of positive and negative electricity; and why should we, reasoning upon the principles of analogy, infer a different principle in the explosion of steam boilers, when the effects produced are the same?

The manner in which these electrical gases accumulate in the clouds I suppose to be this: the positive electricity I suppose to be accumulated in the upper regions of the clouds, and above the clouds containing the water; when these regions become surcharged with positive electricity, it is attracted by the negators, the water-bearers, and the explosion takes place. My reasons for this hypothesis are these: the general direction of electrical explosions is downward; and when there is not negative electricity enough in the lower regions of the clouds to absorb and counterbalance the positive, it reaches to the earth; the rain being then falling, it follows its watery conductor towards, and sometimes to, the ground, according to the quantity and extent of the explosion. The explosion

of lightning, so far as we know, is generally horizontal, or downwards, seldom ascending; and when the same hypothesis is the only satisfactory one which we can find concerning steam-boiler explosions, why should we hesitate to adopt it, especially when we can find no other which is either rational or satisfactory?

If we apply this hypothesis to the steam boiler, the analogical reasonings are: when the surface of the water becomes too low, and consequently the steam chamber too large, the steam remains too long in the boiler in its expanded state exposed to intense heat. From a chemical operation peculiar to the case, different gases, by the constant action of heat, are constantly developed, until the positive electrical gases are formed and accumulated in the upper regions of the boiler, and in such quantity that they are attracted by the negatives, the water below, and then explosion takes place, and is terrible according to the quantity of gas collected and exploded. I only ask any one who has had the misfortune to see or feel the effects of a steam-boiler explosion, or has ever noticed the account of the effects with care, to compare those effects relatively with the effects of the electrical explosion in the heavens, and see if he can find any difference, except the magnitude of the one and the diminutiveness of the other. Is the lightning instantaneous and without warning? So is the other. The lightning, at one effort, and instantaneously, prostrates every thing in its course. So does the steam-boiler explosion. If we have been able by experiment and observation to attain and adopt the true theory of the explosion of the lightning in the heavens, why should we be unwilling to follow the plain principles of reason and common sense in investigating the one subject as the other, especially when those principles and reasonings, in both cases, point to the same causes, and show us the same effects produced?

If any one should ask a more minute description of the manner in which those electrical gases are generated and accumulated in the steam boiler, I would ask him, in turn, how they are formed in the thunder cloud in the heavens? And when he answers my question, his own will be answered also. And it will be noticed, herein, that I do not undertake to explain hidden and unknown things, but simply to give my own opinion, and the reasons for it, and support that opinion by analogy as well as I can. In this case, it is the only mode of reasoning that can be adopted, and the only method that can be taken to lead us to any rational conclusion, because we shall probably never be able to attain it by observation or experiment.

This hypothesis is strengthened by that of Mr. Perkins, as quoted above: that when the water becomes too low, and consequently the steam chamber too large, the steam chamber becomes overchanged with caloric, that is, with electrical explosive gas, without acquiring any additional elasticity, especially if the fire-kiln be bare of water. This caloric I call electrical explosive gas. And we have every philosophical reason to suppose that the effect would be just as he describes it. For, if the expansive power, in such cases, should accumulate in due ratio, its expansive force and effect would be increased in exact proportion, and likewise the motion of the engine; and the boiler would work itself free, and no explosion would take place. And it is natural to suppose that, when the top of the fire-kiln is left bare of water, the heat, which would

otherwise be taken up and dissipated in the water and steam, if the water should cover the fire-kiln, would ascend and remain in the steam, and the electrical gases be accumulated faster.

This opinion of Mr. Perkins accounts naturally for another phenomenon: that when the water and steam, and steam chamber, are thus situated, if a new supply of water be suddenly forced into the boiler, in such quantity as to cover the heated part of the fire-kiln suddenly, the evaporation would be great and sudden, and thereby a conducting medium be flung up towards the surcharged steam, or electrical gas; and then, by the common principles of attraction, the positive electrical gases would be attracted to the negative, the water below, and explosion would necessarily follow, and be dreadful according to the quantity of gas exploded. And these are exactly the effects produced by the experiments of the committee of the Franklin Institute, as related in pages 76 and 77 of their report of experiments and remarks to Congress, and go directly and conclusively to support my theory.

I suppose, also, that these electrical gases are lighter than the steam; for, if they were not, they never could be, as they are, generated, ascend and collect in the upper regions of the boiler. And that they do so ascend and collect is evident from the bare fact that they do collect; for they cannot collect and remain in any other part of the boiler. And if they did not so collect and remain in the upper regions of the boiler, no explosion could ever take place. And because no flame of fire is seen, in cases of explosion, is no objection to this hypothesis; for the quantity of gases exploded is probably vastly less than the quantity of water in the boiler. And farther: by the attraction of these electrical gases by and to the water, the flame is probably all taken up and absorbed in the water before any effect of the explosion becomes visible, or at the instant of explosion.

I have only one remark to make upon the relative safety of high and low press of steam, which is, that both are equally safe, and equally liable to explosion; the phenomenon depending entirely upon the undue largeness of the steam chamber, occasioned by the too low state of the water, whereby room and time are given for the formation of electrical gases. Neither can the strength of the boiler give any security, nor in any manner retard or hasten the catastrophe, if explosion takes place.

I would also notice one other fact concerning explosion. In all the cases which I have noticed, and I believe I have examined all which have been published, I have never seen any account of the lifting of the safety-valve before explosion. This is another strong if not incontrovertible evidence of my hypothesis, that no warning is given of explosion in the steam boiler, any more than of the lightning in the heavens; and that both depend upon the same laws of nature—the natural sympathetic attraction between the positive and negative electricity; and this is another strong analogical proof of their similarity.

And here I would remark, that erroneous notions are probably entertained with regard to positive and negative electricity. By negative electricity it is not to be understood the deprivation of that fluid entirely, but that they are probably distinct species, and answer exactly to the north and south pole in magnetism. It is also probably undoubtedly true, in nature, that the positive is the basis of the male, and the negative the basis

of the female, throughout the whole kingdom of nature. And this accounts naturally for the great and strong sympathy between these two natures, and the tendency they have continually towards each other. This is also another strong analogical argument that explosion in the steam boiler and in the heavens is one and the same thing in nature. And these views show also not only the propriety but also the truth of the names which Dr. Franklin gave them at first, positive and negative electricity; and these names and his principles of electricity have hitherto stood the test of all the cavillings and experiments which ingenuity and ambition have been able to devise ; and they have been many and great, for no pains have been spared to break down the Doctor's theory and establish others.

In most cases of explosion which I have noticed, the engineers have uniformly stated that the boilers have not been overloaded with steam, and, in many cases, not the usual quantity. This is a fact of no consequence ; for the explosion, in my opinion, does not depend in the least upon that circumstance. For it would make no difference, if electrical gases accumulate, and the steam chamber be sufficiently large for that purpose, whether the steam be at one pound, or a thousand, to the inch. It would probably neither delay nor diminish the calamity.

I have one other remark to make concerning the accumulation of electrical gases, which relates to the form and position of the boiler, and the method of taking off the steam. All large engines must necessarily have large boilers. So far as I have examined, the steam is taken off in one place only. Therefore, the progress of the steam towards that aperture, from the surface of the water, is probably conical. Therefore, the steam forming the outer parts of the cone would escape very slowly, and the central parts proportionably faster. This delayed steam, from the constant effect of heat, will naturally become overcharged with caloric : that is, will develop and accumulate electrical gases ; and this process will be apt to proceed according to the largeness of the steam chamber, and the intensity of the heat, and the inertness of the steam, until a sufficient quantity shall be accumulated for the explosion. And it should be noticed that this delayed steam, in proportion as it acquires caloric, loses its elasticity, and, of course, its propensity to escape from the boiler.

Suppose the boiler to be a cylinder, one end higher than the other, and the steam to be taken off in the middle. The higher end would have a recess of all that part above the level of the escape-hole for the steam, which would retain as much steam as its own dimensions. This steam would never escape, on account of its lightness. It would therefore keep undergoing continual changes, from the effect of heat, until it would form those electrical gases proper for explosion, and in time would explode, whenever the other necessary causes should co-operate. Suppose the steam, in this case, should be taken off at the lower end, the recess would be so much larger, and the danger proportionably increased. If the steam should be taken off at the upper end, no recess would be, and the electrical gases would all pass off with the steam ; and, if the water should be kept at a proper height, no danger would ever ensue. And I am inclined to believe, that if a boiler should be laid level, and the water be kept uniformly at a proper height, and the steam taken

off at one place only, no explosion would ever take place. But it would be very little more cost, and no harm, to take the steam off at each end and the middle, and that would secure perfect safety. Fig. I, II, III, IV, and V.

I therefore suggest the following methods:

1. Let the water be kept at a proper and uniform height in the boiler. Fig. VI, and VII.

2. Let the steam, if the boiler is laid level, be taken off at each end and in the middle. Fig. II.

3. If the boiler be laid inclining, let the steam be taken off at the elevated end. Fig. IV.

With these precautions, I am well persuaded that steam engines would be rendered as safe and harmless as a log.

As further proof, if need be, that steam boiler explosions are electrical, I will name a few cases, as well as I can, from memory:

1. I allude to the case of an explosion of an engine at one of the coal mines in England, some years ago. It happened, at the time of the explosion, that no one was in or about the house, and therefore no one was injured. The engine was said to be one of the largest in use. The explosion was so great that it entirely demolished the house, engine, and all the apparatus, and made a complete ruin of the whole. Was lightning ever known to do more, or even so much, at one explosion?

2. I allude to an explosion in one of the line boats between New York and some part of the Jersey shore, I believe Elizabethtown. I believe about ten were killed, and died of their wounds, by this explosion. Two young ladies belonging to New York, who had been on a visit to their friends, and had just gone on board to return home, were among the killed. The engineer was not killed. In his report, afterwards, of the state of the boat and engine, he stated expressly that the boiler, so far as he knew, was strong and in good order; and that very little steam was on at the time, as he was then only heating up, and had not then attained near its working power. And I think he stated that the boiler worked at about ten pounds to the inch. I mention this case not only to show that these explosions are purely electrical, but also that explosion does not depend at all upon a heavy strain of steam at the time, but upon the undue accumulation of electrical gases, and upon the concurrence of the other causes necessary to produce explosion.

If the precautions above mentioned should be adopted, the electrical gases, as they should accumulate, would, in due proportion, pass off regularly, partly in the steam and partly by absorption, back into the water, and thereby explosion would be prevented. And if this theory is true, if the water should be kept at a proper height uniformly, these electrical gases, which should not be carried off in the steam, would be reabsorbed continually, and in such small and regular quantities, that explosion would be prevented. And it is necessary that these gases should be dissipated, in both of these ways, in order to keep up the life of the steam and the life of the evaporation. And this theory accounts also for another fact concerning steam: that it expands in the cylinder; and, for this reason, some engineers cut off the steam at half, two-thirds, or three-quarters of the length of the stroke of the piston, and let expansion carry out the rest of the stroke; and they suppose they

make a saving of power in this way. And the manner of the operation is probably this: the caloric keeps up the heat and strength of the steam in the cylinder, and causes this expansion. And it is necessary that this caloric should be generated: for it is undoubtedly the life and strength of the steam. In the heavens we know that the proper and regular collection and distribution of electricity is necessary to the health, convenience, and growth, of all things, and is the life and soul of the natural world. We know, also, that electricity, in the thunder cloud, is diffusible and expansible in every direction. Why not in the boiler and cylinder? This fluid, though it may put us to some loss, trouble, and expense, in learning how to control it and turn it safely to our account, as well in the steam engine as in the heavens, is not only proper, but absolutely necessary, as well in the one case as in the other, because it is a part of God's works; and we find, so far as we are able to investigate his works, that he has made every thing perfect in its place and kind; and he has told us, in the short account he has given us of the creation, that, when he had made all things, "he saw that it was very good."

The cause of the last named explosion, as I suppose, was the following: When the boat made her run from New York to New Jersey, the water had probably been suffered to evaporate down too low. When the engineer heated up his boiler, to return, he probably, by some accident, forgot to fill up the boiler anew with water. The steam chamber being unduly large, and no steam escaping, the upper part of the boiler being bare, and the water too low to produce a regular reabsorption of the electrical gases, and no steam escaping, the upper region of the boiler became suddenly and unexpectedly surcharged with caloric, and explosion followed, as a matter of course, according to the laws of electricity, by the natural sympathy of attraction between positives and negatives, when a sufficient quantity for explosion is within the reach of those attractions.

I name one other case, as related by Mr. Oliver Evans, of Philadelphia, when at Pittsburg, some years ago, superintending some steam works for that place. It is some years since I have seen the statement, and I do not now recollect in what publication, but the principal facts are now distinct in my recollection. An engine, which was then at work for some mechanical purpose, all at once began to falter, and lose power and speed, without any visible cause, the fire being at its usual height. An unusual and peculiar agitation and distress appeared to be in the boiler. The engineer becoming alarmed, and not knowing the cause, nor what to do, called in Mr. Evans for consultation. He, too, was alarmed, and ordered the fire to be extinguished. The upper part of the boiler, in this case, had become red hot. Mr. Evans's precaution of extinguishing the fire was undoubtedly the very thing which saved an explosion: for, had a new supply of water been forced in, a great quantity of steam would have been instantly generated and flung up towards the etectrical gases already accumulated in the upper region of the boiler; a proper conductor would have been produced between the positives and negatives in the boiler, and an explosion would have instantly taken place. I quote this case to show that Mr. Perkins's opinion, that the accumulation of caloric in the boiler does not add to the

elasticity of the steam, is correct. I quote it, also, as proof incontrovertible that the accumulation of caloric in the boiler not only does not add to, but actually diminishes, the elasticity of the steam, when its quantity superabounds, and in proportion to that superabundance.

Mr. Evans was aware, in this case, that, in certain cases, when the water was suffered to become deficient, and the usual strength of heat kept up, that the steam acquired a non-elastic quality; but did not seem to apprehend nor understand the philosophy of the case, nor the cause, nor remedy, upon philosophical principles, although he hit upon the right remedy.

One other fact is rather collateral than direct proof of my theory: the packing of the piston is frequently charred. This is probably the effect of the caloric, when it passes off in excess. What leads me mostly to this opinion is, that the charring is sometimes produced in a very short time, and at other times it will hold for a long time.

We know that the electrical fluid is only accumulated in the heavens when the moisture is not generally diffused in the atmosphere; for in long and extensive storms the moisture is so diffused that the electric gases diffuse also, and do not accumulate in particular places, positive and negative, and therefore no explosion ever takes place. Apply the same principles to the steam boiler, and the same results will follow; and experience shows that they do. Let the steam chamber become too large, and the caloric will become surplus, and the steam at the top will gradually become dry, electrical gases accumulate, until the quantity becomes large enough for explosion, filling the upper region of the boiler, until they come within the sympathy of attraction of the water, and then explosion takes place. On the other hand, let the negative, the water, be kept so near the top of the boiler as to have just room enough for expansion, and no more, and then the caloric, as it generates, will be carried off in the steam, and reabsorbed back into the water, by attraction, regularly, so as to keep up a proper action of the steam. And I suppose that this absorption back into the water is in such very small and regular quantity as, instead of explosion, to keep up and enliven the process of evaporation. I suppose, also, that just enough caloric is generated in the evaporation of any given quantity of water, when the water is kept at a constant and proper elevation, to keep up the life of the steam as it passes off, and the evaporation by its reabsorption. And when these effects are not produced, the steam becomes too vapory and sluggish; and if the caloric superabounds, it thereby becomes dry and non-elastic. And whoever observes, will find that the same phenomenon takes place in our common atmosphere, according as these principles become plus or minus, either way, and, among the various other effects produced, affect our respiration, and produce energy and elasticity, or languor and debility. With all these natural and analogical reasons, causes, and effects, can any reflecting person doubt that these effects are all produced, both in the heavens and in the steam boiler, by the natural operations of the laws of electricity, especially when no rational account can be given of them upon any other hypothesis.

Having had opportunity to peruse the report of the committee of the Franklin Institute of Philadelphia, made to Congress, upon this subject,

I shall notice a few things contained therein, which go conclusively to affirm my theory. On page 77 they remark, that "the circumstances, as before, show that the steam was allowed to rise gradually, until the boiler gave way. It is possible that there may be a space occupied by the water, and that in which the steam is formed, most favorable to the production of steam, and that when this was attained a rapid rise in elasticity took place; but there were no circumstances observed which would confirm such a view, and, if it were correct, it would only affect the conclusion, as far as the increase of tension might have been rapid from such a cause."

I suppose the gentlemen here mistook the case, by going upon the mechanical instead of the philosophical principles of the case. They say that "no circumstances were observed which would confirm the view that any additional pressure was in the boiler at the time," though they still suppose that a gradual increase of pressure took place until explosion. From the facts laid down by them, I should reason the other way. The effects shown by them to have taken place prove conclusively that it was not simply a bursting, but an explosion, according to my distinctions, above made, between bursting and explosion. From the time of first evaporation, till the positives and negatives became equal, a regular increase of pressure would naturally take place. From the time that the caloric began to predominate, till the explosion, the pressure might continue the same, or might increase or decrease, and no visible appearance could determine which. If it had been a bursting by mere pressure, it would have made one aperture at the weakest place, and blown off the steam, and no more. The effects produced were the instantaneous destruction of the boiler, and, therefore, must have been an explosion.

In page 78 they remark, that "these experiments, together with the one referred to in a subsequent part of the report, are direct and conclusive, that all the circumstances attending the most violent explosions may occur, without a sudden increase of pressure within the boiler." This also affirms the doctrine which I have laid down and explained above, though they give no reason for it. They add, "there can be no doubt, however, that, if particular portions of the boiler are much weaker than the others, they may give way in time to prevent such a catastrophe." This would depend, not on the strength or weakness of the boiler, as I have heretofore shown, but upon the simple fact, whether it was a bursting or an explosion.

On pages 80, 81, and 82, the committee have made sundry experiments, to ascertain whether "causes may really occur, when the safety-valve, loaded with a certain weight, remains stationary, while the confined steam requires a higher elastic force than that which, from calculation, would appear necessary to raise the valve." I need here to go into no speculation about safety-valves, and their methods of construction. I have above fully related the philosophical difference between bursting and explosion, and those reasons cover the whole ground here, if my theory is right. This report, upon mechanical principles, is very learned and able, and has done great honor to the Institute; and they seem to me to have gone wholly upon mechanical principles, and to have taken no notice of the philosophy of the case. If it is, as I suppose, wholly a phil-

osophical subject, we never can explain it upon mechanical principles; and if we do not finally settle the principles right, we shall not be likely to hit upon the right remedy; and we must, in all cases, understand that the laws of nature never run after us, but we must, with care and patience, search them out.

On page 39 they quote sundry experiments and results made in Europe, upon certain alloys, which will melt and give way at certain temperatures of heat. They give also the form of the apparatus used, and the alarm-bell attached to it.

This may be a species of safety, but I doubt if it can be relied upon at all as a standard, and for the following reasons: I have shown above that explosion does not depend at all upon the degree of pressure in the boiler at the time. 2d. If my theory is true, it does not depend wholly upon the degree of heat in the boiler neither, though there must be heat enough to generate the explosive gas, as above shown. But if the water be kept constantly at its proper height in the boiler, and the steam be properly and regularly taken off, all the heat that can possibly be applied would only increase the quantity of steam, but could never make an explosion, nor have any tendency thereto. 3d. Explosions have taken place when the heat has not been intense; therefore, the probability is that explosion may take place when the heat is not sufficient to melt the alloy. In such case this apparatus would be no safety at all, but rather a decoy. 4th. And this very giving away of the alloy might be the immediate cause of explosion; for if the boiler should be then very near the point of explosion, and this alloy should melt and open the aperture, this would ease the pressure on the water, and let it rise, by its ebullition power, towards the positive gases, bringing the positives and negatives within the reach of their sympathy of attraction, and then explosion would take place, of course.

My design is not to have any danger, nor any occasion to give warning of it, but to foreclose and prevent all its causes. In the management of health, it is a much better plan to prevent diseases than to cure them. Why not apply the same principle to the steam boiler?

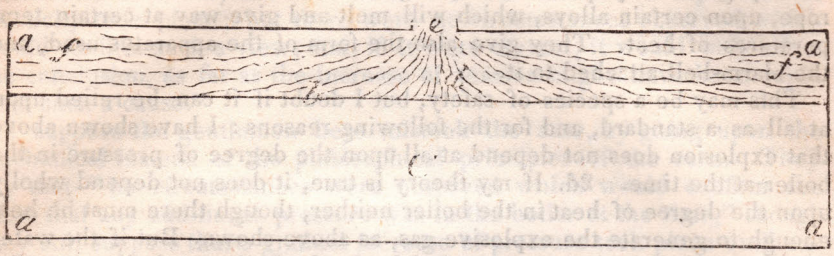
For the purpose of keeping the water constantly at a uniform height in the boiler, a very cheap and effectual apparatus may be applied to it. With this apparatus the water can be put at any given height, and never vary more than a quarter of an inch. This method of filling the steam boiler requires less labor of the engine than the common method, by the force-pump. For further explanation I refer to the drawings, Fig. VI and VII.

As collateral proof of my theory, I would also notice several other kinds of explosion produced by heat and water: 1. That of slacking lime, by pouring water on it. This is done by the attraction of the positives and negatives. 2. The method practised by blacksmiths in scaling the iron, as they call it, by throwing water on the anvil, and then laying a hot iron on it and striking a blow. This removes the sand scale, with a loud report and great explosion, for so small a quantity of water.

If these steam boiler explosions are upon the same principles as the electrical explosion in the heavens, perhaps some might suggest the propriety of taking off these positive electrical gases by rods, after the method of taking the electric fluid from the clouds. I give no opinion whether

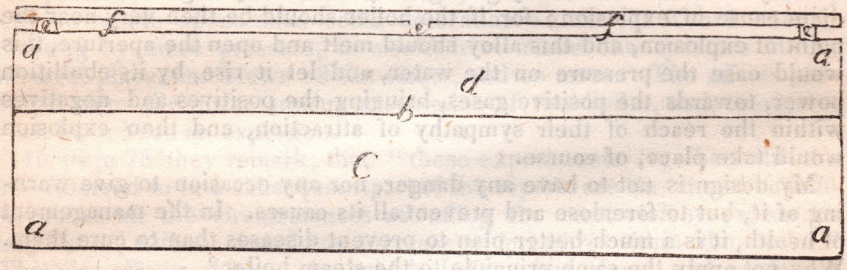
this could or could not be done. If it could, and it should be done, the life of the steam would probably be destroyed; so we must turn our attention to the best and most practicable method of controlling it, and rendering it harmless and subservient to our convenience.

Fig. I represents the boiler standing level, and the steam taken off in the middle.



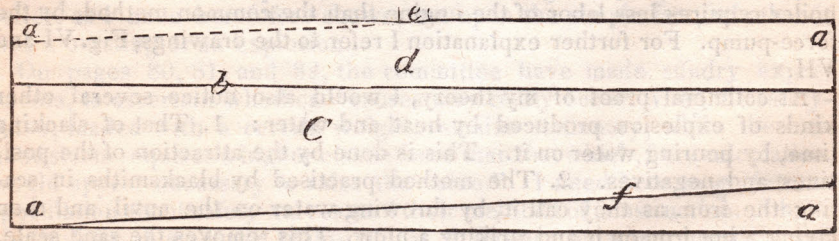
a represents the boiler, *b* the water line, *c* the water chamber, *d* the steam chamber, *e* the outlet for the steam, *f* that part of the steam chamber where the caloric would be likely to fall off and remain. The conical work represents the conical gathering of the steam towards the escape-hole.

Fig. II represents the boiler standing level, and the steam taken off at each end and in the middle.



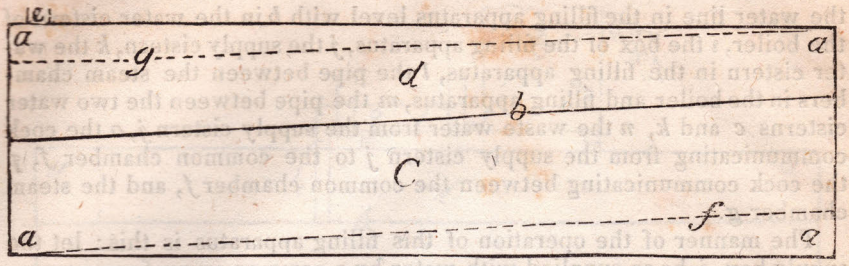
a represents the boiler, *b* the water line, *c* the water chamber, *d* the steam chamber, *e* the outlets, *f* pipe to conduct off the steam.

Fig. III represents a boiler inclining, and the steam taken off at the middle.



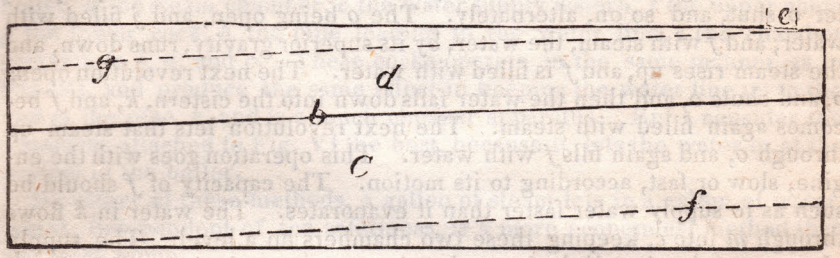
a represents the boiler, *b* the water line, *c* the water chamber, *d* the steam chamber, *e* the outlet, *f* the level below which the dirt, &c., will settle, *g* the level above which the caloric will rise and remain, and can never escape.

Fig. IV represents a boiler inclining, and the steam taken off at the lower end.



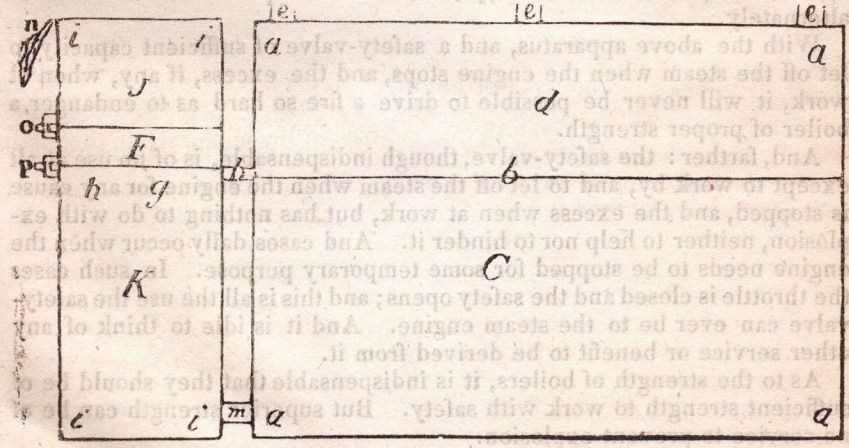
a represents the boiler, *b* the water line, *c* the water chamber, *d* the steam chamber, *e* the outlet, *f* the level below which the dirt will settle, *g* represents the line of level of the steam chamber.

Fig. V represents a boiler inclining, and the steam taken off at the lower end.



a represents the boiler, *b* the water line, *c* the water chamber, *d* the steam chamber, *e* the outlet, *f* the line of level below which the dirt will settle, *g* the line of level above which the caloric will rise, and can never escape.

Fig. VI represents a boiler laid level, the steam taken off at each end and the middle, and the filling apparatus attached to it.



a represents the boiler, *b* the water line, *c* the water cistern, *d* the steam chamber, *e* the outlets for the steam, *f* the chamber in the filling apparatus common to *j* and *k*, *g* the steam chamber in the filling aparatus, *h*

the water line in the filling apparatus level with *b* in the water cistern of the boiler, *i* the box of the filling apparatus, *j* the supply cistern, *k* the water cistern in the filling apparatus, *l* the pipe between the steam chambers in the boiler and filling apparatus, *m* the pipe between the two water cisterns *c* and *k*, *n* the waste water from the supply cistern *j*, *o* the cock communicating from the supply cistern *j* to the common chamber *f*, *p* the cock communicating between the common chamber *f*, and the steam chamber *g*.

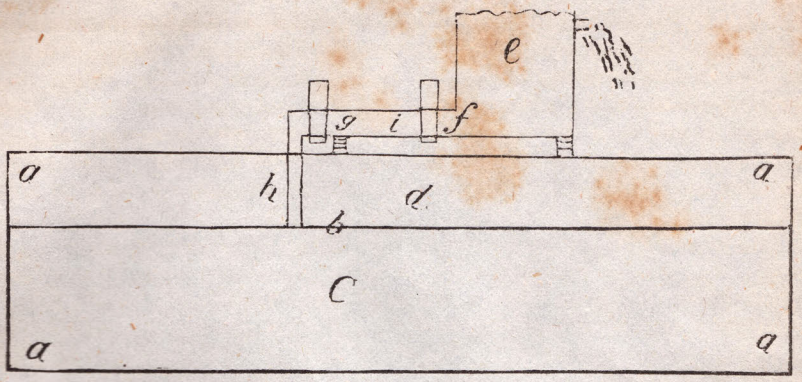
The manner of the operation of this filling apparatus is this: let the supply box, *j*, be so supplied with water by a common pump from a reservoir underneath, that a little water shall always run at the waste-hole, *n*, and then it will be certain that a full supply of water is always had, and let the waste run back into the reservoir below. Then let the two cocks work alternately: when *o* is open, let *p* be shut. Their levers should be hitched together, and worked by the engine. Then, when *p* opens, let *o* shut, and so on, alternately. The *o* being open, and *j* filled with water, and *f* with steam, the water, by its superior gravity, runs down, and the steam rises up, and *f* is filled with water. The next revolution opens *p*, and shuts *o*, and then the water falls down into the cistern, *k*, and *f* becomes again filled with steam. The next revolution lets that steam up through *o*, and again fills *f* with water. This operation goes with the engine, slow or fast, according to its motion. The capacity of *f* should be such as to supply water faster than it evaporates. The water in *k* flows through *m* into *c*, keeping these two chambers on a level. The supply of water coming in a little faster than it evaporates, the water line, *b* and *h*, will gradually rise till the water will choke the cock, *p*. Then *f*, *p*, and *o*, being all filled with a fluid of one gravity, they will open and shut, and nothing pass up or down, until the water wastes in the boiler so as to again uncover the cock, *p*, and let the steam into it; and then the former operation will be renewed, and the water supplied again until it shall again rise and choke the cock, *p*; and so these operations will continue alternately.

With the above apparatus, and a safety-valve of sufficient capacity to let off the steam when the engine stops, and the excess, if any, when at work, it will never be possible to drive a fire so hard as to endanger a boiler of proper strength.

And, farther: the safety-valve, though indispensable, is of no use at all except to work by, and to let off the steam when the engine for any cause is stopped, and the excess when at work, but has nothing to do with explosion, neither to help nor to hinder it. And cases daily occur when the engine needs to be stopped for some temporary purpose. In such cases the throttle is closed and the safety opens; and this is all the use the safety-valve can ever be to the steam engine. And it is idle to think of any other service or benefit to be derived from it.

As to the strength of boilers, it is indispensable that they should be of sufficient strength to work with safety. But superior strength can be of no service to prevent explosion.

Fig. VII represents a boiler with the filling apparatus on the top.



a represents the boiler, *b* the water line, *c* the water cistern in the boiler, *d* the steam chamber, *e* the water supply cistern, *f* the upper cock, *g* the lower cock, *h* the pipe leading to the water line, *i* the chamber common to *e*, *d*, and *c*. These cocks operate in the same manner as in Fig. VI, and produce the same effect in keeping the water line up to the end of the pipe, *h*, and is a much cheaper apparatus. But I consider the apparatus attached to Fig. VI the best, because it lets the water in at the bottom of the boiler.

By either of these methods, a gallon of steam lets in a gallon of water, which, independent of the safetiness, is a more economical method than the force pump.

I suppose I have pretty well unfolded my views of this case, but some farther remarks could be made if necessary.

JONATHAN MORGAN.

PORTLAND, MAINE, *January* 4, 1838.